Joint Swift-INTEGRAL Observations and Plans

Neil Gehrels & Jack Tueller - NASA/GSFC

INTEGRAL Workshop
Sardinia
Ocotober 17, 2007

Outline

Long GRBs

Collapsar Understanding

Short GRBs

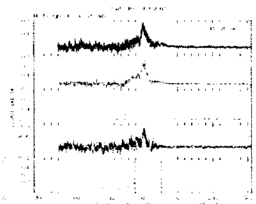
Afterglow

Reduced Trigger Threshold

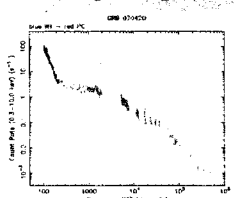
Hard X-ray Sky Survey

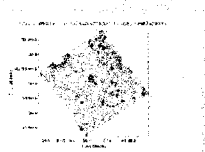
Swift GRB from April 20

BAT prompt emission



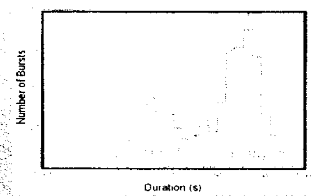
XRT afterglow lightcurve





UVOT images

Long GRBs

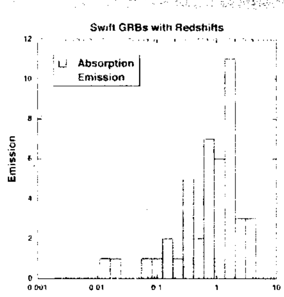


Kouveliotou et al. 1993

60 *Swift* Long GRB Redshifts

$<z> = 2.3$

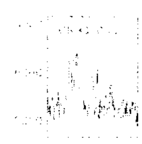
6.29	050904	2.35	070110
5.47	060927	2.31	070506
5.3	050814	2.30	060124
5.11	060522	2.20	050922C
4.9	060510B	2.04	070611
4.41	060223A	1.95	050315
4.27	050505	1.71	050802
4.05	060206	1.55	051111
3.97	050730	1.51	060502A
3.91	060210	1.50	070306
3.71	060605	1.49	060418
3.69	060906	1.44	050318
3.53	060115	1.31	061121
3.44	061110B	1.29	050126
3.43	060707	1.26	061007
3.36	061222B	1.17	070208
3.34	050908	0.97	070419A
3.24	050319	0.94	051016B
3.21	060926	0.84	070318
3.21	060526	0.83	050824
3.08	060607A	0.76	061110A
2.95	070411	0.70	060904B
2.90	050401	0.65	050416A
2.82	050603	0.62	070612A
2.71	060714	0.61	050525A
2.68	060604	0.54	060729
2.61	050820A	0.44	060512
2.50	070529	0.125	060614
2.43	060908	0.089	060505
2.35	[illegible]	0.033	060218



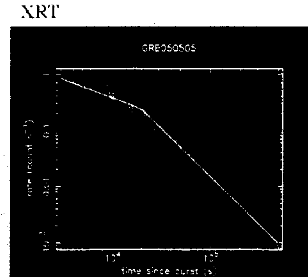
GRB 050505

z = 4.27
Duration = 60 s

BAT

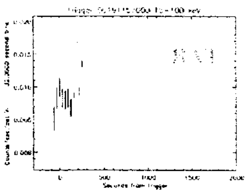


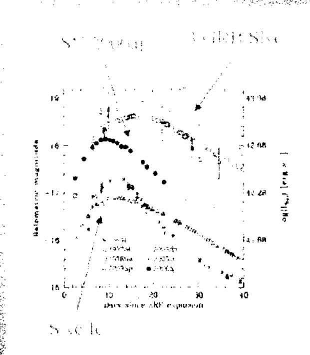
XRT



z	GRB	Optical/IR Brightness
6.29	050904	J = 18 @ 3 hrs
5.6	060927	I = 16 @ 2 min
5.3	050814	K = 18 @ 23 hrs
5.11	060522	R = 21 @ 1.5 hrs
4.9	060510B	J = 19 @ 2 hr
4.41	060223A	V = 18 @ 1 min
4.05	060206	V = 17 @ 1 min

GRB 060218: GRB + Supernova





Super-long GRB - ~35 minutes

BAT, XRT, UVOT during GRB

z = 0.033 d = 145 Mpc

SN 2006aj SN Ib/c

E_{iso} = few x 10^{49} erg - **underluminous**

E_{peak} = 5 keV (XRF)

Campana et al., Mazzali et al., Pian et al., Soderberg et al.

Short GRBs

Short GRB - Current Status

Swift short GRB observations

- 18 short bursts detected (+ 2 from HETE)
- 78% with X-ray afterglow detected by XRT (95% long GRBs)
- 28% with optical detection (58% long GRBs)
- ~50% with host IDs

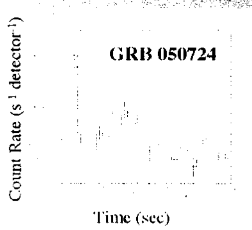
~1/2 shorts accompanied by soft extended emission up to 100 sec

Redshift range from z = 0.2 to ~2

- $\langle z \rangle_{short}$ = 0.6
- $\langle z \rangle_{long}$ = 2.3

Afterglow weaker than long GRBs

- $\langle F_X \rangle_{short} = 7 \times 10^{-10}$ erg cm^{-2} s^{-1} (@ t_o+90s)
- $\langle F_X \rangle_{long} = 3 \times 10^{-9}$ erg cm^{-2} s^{-1} (@ t_o+90s)



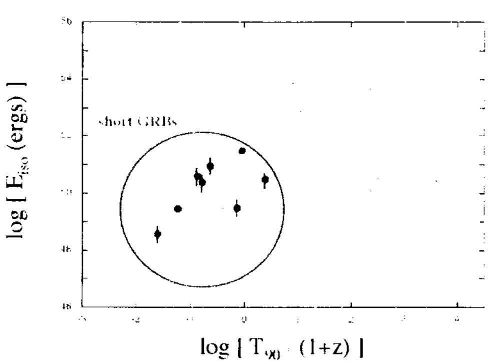
Short GRB Redshifts

6.29	050904	2.04	070611
5.47	060927	1.95	050315
5.3	050814	1.71	050802
5.11	060522	1.55	051111
4.9	060510B	1.51	060502A
4.41	060223A	1.50	070306
4.27	050505	1.49	060418
4.05	060206	1.44	050318
3.97	050730	1.31	061121
3.91	060210	1.29	050126
3.71	060605	1.26	061007
3.69	060906	1.13	060801
3.53	060115	1.17	070208
3.44	061110B	0.97	070419A
3.43	060707	0.94	051016B
3.36	061222B	0.84	070318
3.34	050908	0.83	050824
3.24	050319	0.83	061217
3.21	060926	0.76	061110A
3.21	060526	0.70	060904B
3.08	060607A	0.65	050416A
2.95	070411	0.62	070612A
2.90	050401	0.61	050525A
2.82	050603	0.55	051221A
2.71	060714	0.54	060729
2.68	060604	0.44	060512
2.61	050820A	0.41	061210
2.50	070529	0.296	050826
2.43	060908	0.258	050724
2.35	051109A	0.225	050509B
2.35	070110	0.125	060614
2.31	070506	0.111	061201
2.30	060124	0.089	060505
2.26	050922C	0.033	060218

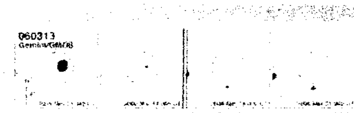
red = short GRBs

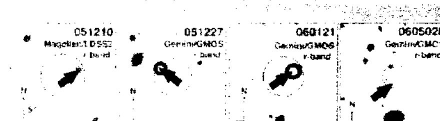
Three Groups

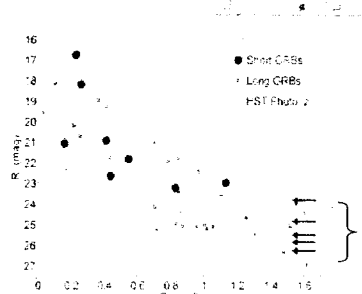
Swift GRBs (mostly)



Faint Short Hosts
Large Distances



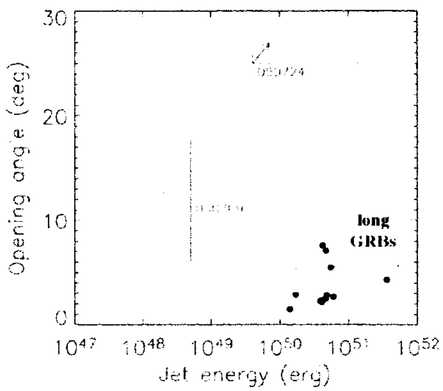




short host magnitudes

Berger et al. 2007

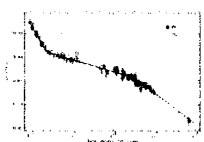
Short GRB Beaming

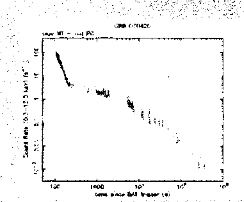


Burrows et al.

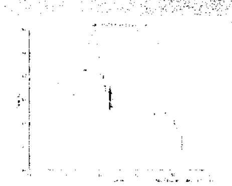
Afterglows

Typical *Swift* X-ray Lightcurves



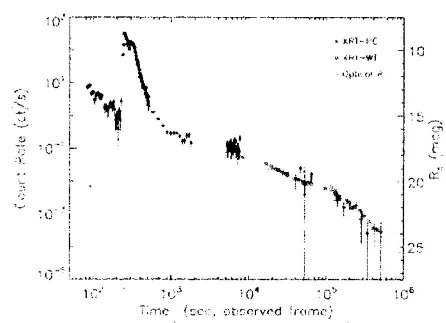


50% with bright early component



>30% with flares

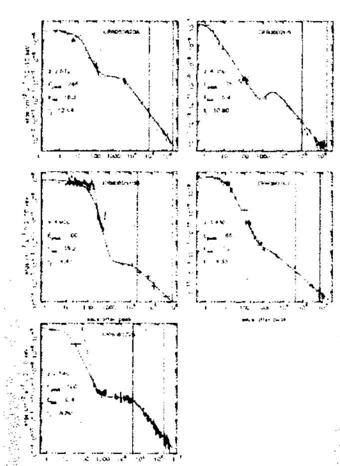
Achromatic Jet Break - GRB 060526



z=3.21
jet angle = 7°

Dai et al. 2007

Puzzling Data



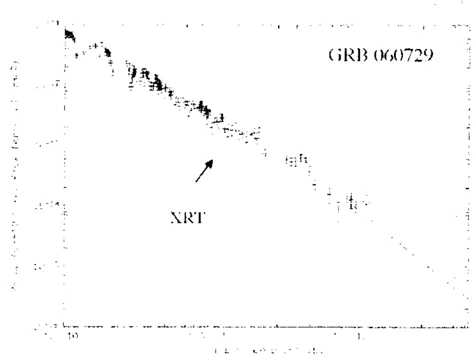
- Many GRBs do not show jet breaks
- In many other cases, optical and X-ray breaks are not coincident
- Complex shape of afterglow lightcurves makes jet break hard to find

Some argue that there is some evidence for achromatic breaks in many Swift GRBs

Willingale et al. 2007

Curran et al. 2007

GRB 060729 - Long Afterglow



Limit on jet angle
θ > 23°

(Sari et al. equation
n = 0.1 cm⁻³
eff$_\gamma$ = 0.2)

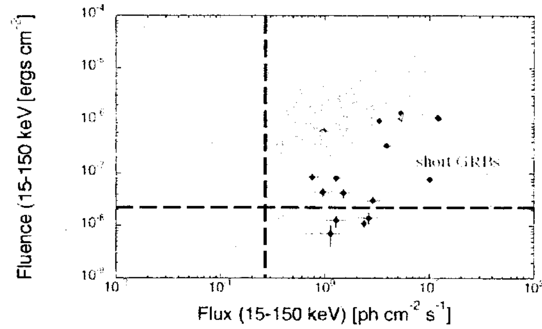
$E_\gamma > 2 \times 10^{51}$ erg

Grupe et al. 2007

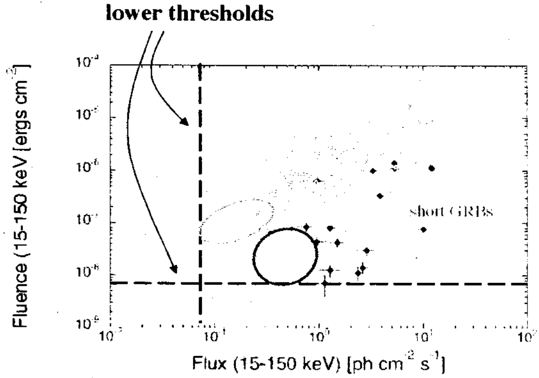
New Initiatives

- **GRBs from slew data**
  - Collaboration with Grindlay group
  - Extra ~10 GRBs/yr
- **Lower BAT trigger thresholds**
  - 1-2 spacecraft slews per day
  - Real GRBs recognized by
    - XRT/UVOT detection
    - Coincidence with nearby galaxies
  - Real GRB rate unknown, perhaps 20 GRBs/yr

BAT Fluence and Flux Limits

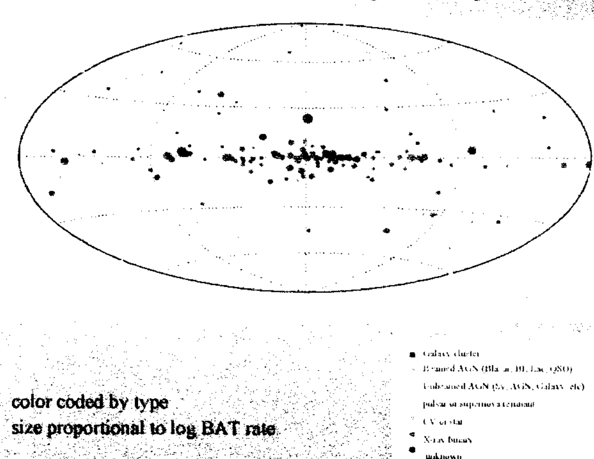


BAT Fluence and Flux Limits



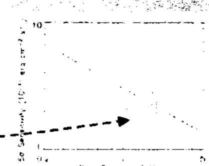
BAT Sky Survey

BAT Hard X-ray Survey



color coded by type
size proportional to log BAT rate

Survey Results and Implications



- At 22 months 526 sources are detected
- **Sensitivity is ~1 mCrab all sky**
- Errors still dominated by statistics
- Early results
  - 15 gamma-ray blazars (one at z=3)
  - 3 symbiotic stars
  - **Absorbed AGN (Sy 2's) are ~60% of BAT AGN**
    - ⇒ Absorbed systems dominate AGN population in unbiased samples
- **Implications**
  - **First complete knowledge of local AGN population**
  - **7% of luminous (~L*) galaxies in local universe have AGN**